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"The last clause of the first section of said Act, shall not be so construed as to apply to any debt due from one bank to another, and this Act shall take effect immediately."

The facts presented in the foregoing pages afford an ample illustration of the effects of free institutions, and the general diffusion of intelligence, whilst they exhibit one of the most remarkable instances of the rapid growth of a civic community which the history of the world can furnish. If the experience of the last twenty years may be taken as an indication of the future progress of the city of New York, its commercial greatness is yet far from having attained its acmé, and the sanguine anticipations of many of its citizens will no doubt prove justified by the result. What those anticipations are may be shewn by the following extract from one of the Reports of the Common Council,* with which I conclude this paper:—

"Look where we will we cannot find any city that promises to excel our own. It is the first hope of all who leave Europe, the preference of navigators, and decidedly the best resort for capitalists. It is the central city; the natural depôt for the reception and distribution of merchandise; the granary and store-house for a mighty continent, that is on the resistless march to wealth and pre-eminence.

"With a present population of nearly 300,000 souls (1836), steadily and rapidly increasing, a climate conducive to health, and possessing all the natural and artificial means to encourage the various branches of trade, it may confidently be anticipated, that within the next half century our city will contain a million of inhabitants, and control a commerce second only to that of the first city in the Old World."

On the Value of the Numerical Method as applied to Science, but especially to Physiology and Medicine. By William Augustus Guy, M.B., Cantab. Professor of Forensic Medicine, King's College, London.

"Medicina est ars conjecturalis."—More than eighteen centuries have elapsed since this sentence was penned by the Roman writer; but time, though it has somewhat restricted its application, has scarcely impaired its truth. Within a comparatively recent period many branches of human knowledge, which were originally as conjectural as medicine itself, have attained to high degrees of certainty; and sciences, the creation as it were of yesterday, have grown to sudden completeness: but medicine, the oldest, and for a time at least the most advanced of all the branches of human knowledge, still remains a conjectural art. Is this conjectural nature of our art *necessary* or *accidental?* does it depend on difficulties inherent in the subjects of our study, or on certain defects in our methods of investigation? I know of no way in which this question can be better answered, and the peculiar difficulties which beset the study and the practice of our profession better illustrated, than by comparing the means which we employ for the investigation of truth with others which may be resorted to for attaining the same end,—than by contrasting, in fact, the more perfect sciences with our own.

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* Report of the Committee on Wharfs.

Of all the means of arriving at truth, the most simple, and at the same time the most certain, is abstract reasoning. It is true that *reason* must bear a part in all our investigations. Without her aid neither observation nor experiment could be directed to useful purposes, efficiently performed, or practically applied; but there is one class of subjects which forms, in a more especial manner, the province of abstract reasoning. I mean number — magnitude — quantity. For it is clear, that with regard to these we can lay down certain definitions which cannot be misunderstood, and make certain assertions which can neither be doubted nor denied. Who, for instance, can misunderstand the definition of a circle or a square, or doubt that the whole of any thing is greater than a part of it, or that things which are equal to the same thing are equal to one another? Now, reason, availing herself of these simple materials, a few plain definitions, and a few self-evident truths, and substituting, where it is practicable, signs for language, and symbols for expressions of quantity, (with a view of ensuring brevity, avoiding misconception, and furnishing expressions of greater generality than those employed in ordinary language,) has arrived at the most extraordinary results. Her first care, if I may so express myself, has been to procure instruments of calculation applicable alike to the most insignificant and to the most stupendous objects—alike to the atom, which from its minuteness escapes the cognizance of our senses, and to the world, which distance removes beyond the sphere of our vision; alike to the comparatively small masses, movements, distances, of the objects presenting themselves upon our earth, and to the vast masses, the enormous distances, the almost inconceivable velocities of the heavenly bodies. In procuring these instruments of calculation reason avails herself of no doubtful aid, neither of that of the senses, which indeed too often deceive us, nor of observation and experiment, which may fail, either from being badly directed or inefficiently performed; but, depending entirely on her own unaided powers, and possessing in them not merely instruments of discovery but tests of truth, the results at which she ultimately arrives are stamped with the seal of certainty.

It is in procuring these instruments of calculation that the work of unassisted reason may be said to terminate; but here begins that union of *reason* with *observation* and *experiment* which has reared the noblest monument, and achieved the proudest triumph of human intellect. It is to this application of the instruments of calculation to the materials furnished by observation and experiment, that we owe the so-called mixed mathematical or exact sciences. These sciences differ in their degree of certainty, some of them being scarcely less certain than the results of abstract reasoning itself, and others scarcely more perfect than the least-favoured sciences of observation and experiment. As a general rule, however, it may be stated, that their degree of certainty is exactly proportioned to the extent to which they admit of the application of numbers. This statement, the truth of which is borne out by all scientific experience, and broadly asserted by those who are best fitted to form a judgment concerning it, is well illustrated by the science of astronomy. This is beyond all others a science of calculation; the relations of time, space, order, magnitude, and velocity (the great objects of its research), all admit of being expressed by numbers; the observations to which the astronomer applies his calculations are, strictly speaking, numerical; and even the beautiful theory of gravitation, by which the several detached facts were formed into a compact and perfect science, is a numerical theory. Hence it is that astronomy takes the lead among the applied sciences, and forms the model of a perfection which all of them strive to imitate. If time permitted, I might pass in review the several mixed mathematical sciences, and shew that they form a descending scale of perfection, whose degrees are marked by the extent to which they admit of the application of numbers. But I must not omit to mention one science, which, forming as it does a necessary part of the studies of every medical man, will afford a striking illustration of the position which I am endeavouring to maintain — I mean the science of chemistry. Not many years ago chemistry was a mere *art*, consisting of a great number of detached observations and experiments of the highest interest, and of the greatest practical importance, but still it did not deserve the name of a science. The application of a numerical theory — that of definite proportions — at once brought together the scattered members of which it consisted, and formed them, so to speak, into a living whole, on which were thus conferred the dignity of a science and the gift of prophecy. So great is the power which this numerical theory has given to the chemist, that one or two simple data, furnished by experiment, enable him to foretell the changes which will take place among the atoms of matter, with the same certainty with which the astronomer predicts the occurrence of an eclipse or the appearance of a comet.

If, then, calculation is capable of conferring such benefits upon science, why, it may be asked, has it not been more extensively employed? why has it not been applied alike to all the sciences of observation and experiment? The answer to this question is not difficult, and as it has an important bearing on our subject, I shall discuss it at some length.

The first attempt to employ calculation in aid of science was both the most obvious and the most successful which has yet been made. But little reflection was necessary to discover that as number itself is an abstract idea, entirely independent of the varying forms and properties of the things counted, so the most successful application which can be made of number is to those "primary existences and relations" which are themselves abstract, and which, even if matter had no existence, "we could not even conceive not to be." * Such are space, time, order, &c. To these, which are in their very nature numerical, we may add certain relations of matter, such as relative position and distance. It was to these last that the *instruments of calculation* of which I have already spoken were first applied. As this term, *instrument of calculation*, has been more than once employed in a sense distinct from the mere use of numbers, I shall explain, by one or two examples, the meaning which it is intended to convey.

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* Sir J. Herschel, "Discourse on the Study of Natural Philosophy," p. 18.

The *angle*, for instance, is the measure of position and direction. Now, the size of an angle is independent of the length of the lines which form it; it may, therefore, be employed to ascertain the position of the nearest as well as of the most distant, of the smallest as well of the largest, objects: it is applied with the same ease and certainty to worlds as to atoms, and measures with equal precision the direction of the ray of light which emanates from the remotest of the fixed stars, and of that which is reflected from the surface of a crystal. The angle, in fact, is a measure of position without regard to distance or to magnitude, a measure of direction without reference to the length of the real or imaginary straight lines by which direction is indicated.

We can easily foresee the important purposes to which such an instrument of calculation may be applied. Wherever two points exist, there the angle may be employed to ascertain their position; wherever two lines exist (whether those lines be real or imaginary, drawn on paper or traced in sand, or supposed to extend from the remotest visible point to our eye), there the angle becomes a measure of their direction. The position of a single object, or the direction of a single line, may also be determined by means of points or lines arbitrarily assumed. Light, emanating from luminous objects, travels to our eye in straight lines; the direction of the rays of light, therefore, is at once submitted to measurement: motion, abstraction being made of all adventitious resistance, takes place in straight lines; the direction of a moving body may therefore be calculated. The direction of the rays of sound, heat, and electricity, may be ascertained by the same simple means, and thus the angle becomes a powerful instrument of calculation applicable to all those sciences in which position and direction, considered as abstract relations of matter, bear a part.

No less powerful and certain in its application is the *triangle* as a measure of distance. The properties of the triangle, like those of the angle, are altogether independent of the length of the lines which form it. Provided that the angles of any two triangles be equal each to each, the sides will bear precisely the same proportion to each other in both, and in either case, certain parts of the triangle being known, the rest can be calculated. The application of the triangle, as an instrument of calculation, is co-extensive with that of the angle. Where the angle determines the position of an object with regard to any other object, or to any point or line arbitrarily assumed, the triangle measures the distance of that object: where the angle determines the direction of a ray of light, heat, or sound, the triangle may be applied to ascertain the distance of the source from which the light, heat, or sound, emanates: where the one is used to trace the direction of motion, the other may be employed to find the amount of that motion, or, in other words, the distance of the moving force from the point at which the moving body comes to rest. In like manner, also, as the angle measures position and direction without regard to distance, so the triangle measures distance without regard to magnitude. Thus nearly the same methods are employed to ascertain the height of the mountain which we cannot scale, or the breadth of the river which we cannot cross, as to determine the distance of the most remote of the heavenly bodies from each other, or from our planet.

The angle and triangle have been adduced as examples, and by way of illustration merely; but if we possessed no other instruments of calculation than these, we should be prepared to construct sciences of vast extent, and, as far as they went, of absolute certainty. The position and distance of every object which we could perceive, of every point, however minute, which the eye, aided by the most delicate and powerful instruments, could descry, would be determined, and thus the broad foundations of geometry and astronomy would be laid; the direction of the rays of light, heat, sound, electricity, &c., would be subjected to measurement; every motion which took place in straight lines, whatever might be the cause of it, would obtain a measure both of its direction and amount; and the form of every material object which presented regularity of outline and symmetry of parts would be described and measured with accuracy and precision. Wherever, in fact, abstract properties and relations of matter formed the objects of science, wherever position could be represented by a point, or direction by a line, there abundant materials would be collected, ready for the application of those higher theories which give to sciences already certain their last finish and completeness.

The cause of the superior certainty of astronomy, optics, and dynamics, will now be evident. These sciences deal chiefly with the abstract properties and relations of matter, which admit of being represented by points and lines, and give free scope to the application of the various instruments of calculation which abstract reasoning has invented. But even these sciences are not absolutely perfect. Although, as speculative sciences, they deal chiefly with the abstract relations of matter, as practical ones they encounter at every step forms of matter possessed of distinct and peculiar properties; some of these forms of matter are employed in the manufacture of instruments by which we aid our imperfect senses, and others exercise a material influence in modifying the impressions made on those senses. The amount of that influence must be determined by experiment before we can place full reliance on the observations to which our calculations are to be applied. For instance, till the refractive power of the atmosphere was experimentally ascertained, and allowance was made for it in our observations, the apparent, and not the real, position of distant objects was all that could be determined; in like manner, till the manufacture of lenses for our telescopes was improved, the unequal refraction of the rays of light introduced uncertainty into the observations made by means of these instruments. Till our knowledge, therefore, of the properties of the matter of which our instruments are made, or to which our observations are directed, is complete, we cannot hope to attain to certainty.

The study of the properties of the several forms of matter is the next object, therefore, which we have in view, and the numerical expression of these properties constitutes a second series of instruments of calculation of much more limited application than those we have already considered, but capable of attaining to nearly the same degree of certainty. The determination of these numerical values is the object of observation and experiment. It is by these that we have discovered the laws which regulate the expansion of solid, fluid, and æriform bodies by heat, the pressure of the atmosphere at different elevations, the velocities of the several imponderable fluids, and the proportions in which the several elementary substances combine. These, and a thousand other facts numerically expressed, become so many instruments of calculation prepared to our hands and ready for our use. It is not till these numerical expressions assume a regular shape, and admit of being stated in abstract terms, that we place full reliance on their accuracy; and we require, for the most part, their repeated re-application to the form or condition of matter from which they were derived before we employ them with all the confidence which we readily place in the results of abstract reasoning.

These numerical values have every degree of generality. Some of them apply to all forms of matter alike, as gravity; others to one state or condition of matter only, as the laws which govern the motions of fluids; and others again to but one species of matter, as the refraction of light by air, glass, or the diamond. These values, once accurately ascertained, can be re-applied with certainty to matter in every respect *identical* with that from which the calculation was first derived. But here the natural philosopher has a difficult task to perform; he has to ascertain by the use of his senses, or by the aid of instruments, the identity of the form of matter to which his calculations are to be applied with that from which they were originally derived, and as his senses may deceive him, and his instruments be wanting in delicacy and accuracy, errors may creep in. The employment, therefore, of calculations derived from experiments or observations on the various forms and states of matter will be open to this source of fallacy, and the results obtained will be, in many cases, of inferior certainty to those which the more perfect instruments of calculation, applied to the more abstract properties of matter, furnish. It must be self-evident, indeed, that it is much more difficult to identify any form or state of matter than to determine position or direction. Still, close and accurate observation, aided by instruments of improved construction, may ultimately bring the sciences in which these more limited calculations play a prominent part, to a perfection little inferior to that which astronomy, optics, and dynamics, have obtained.

But here we reach the limits of possible certainty, and enter upon the wide domains of probability. We have hitherto restricted the use of calculation to the abstract properties and relations of matter to the various agents by which the material universe is governed and controlled, or to those forms of matter of which one portion is identical with every other. But this leaves untouched a vast variety of objects to which calculation has been extensively and successfully applied, with no hope of attaining certainty it is true, but preferring probability expressed by numbers to the most exact phrases of ordinary language.

The objects to which I allude are such as undergo frequent and irregular changes, and have hitherto defied all attempts to apply to them any exact and unvarying measure—as, for instance, the atmosphere, which, in respect of density, temperature, humidity, and electric condition, is constantly varying, or the tides and winds. Another class of objects consists of those substances which bear the same name, and have a close resemblance to each other, without being identical. Some of these substances belong to the world of inanimate matter, and having been submitted during their formation to influences of varying intensity, differ from each other in form and structure, as coal, and the several varieties of ores and stones; others again have been endowed with life, and have arrived at different ages and different degrees of development under external circumstances of infinite variety, as wood, horn, bone, &c.; and others again are to a greater or less extent the work of men's hands, and for that very reason can rarely be identical; such are the various metals extracted from ores, and the articles into which they are wrought, as chains, wires, &c. Now these several materials are extensively employed in the arts of life, and it is of the greatest importance to know their exact properties anterior to their employment; but as the wood which comes from the same tree is not of equal hardness throughout, as one specimen of iron has not precisely the same properties as another, as ropes, or chains, or wires, to all outward appearance identical, are found to support different weights, and to allow of different degrees of tension, it becomes necessary to ascertain the *probable*, and not the actual strength, &c., of the materials we are about to use; to find, in fact, the mean of a number of quantitative values, and employ it as the best substitute for those certain calculations which, having been derived from experiments on the several states and forms of matter, are re-applied to others in every respect identical with them.

Here, then, is the first application of the numerical method, and for a long time this was its only application. The advantage attending its employment is so obvious, that no practical man has ever dreamed of substituting for it the indefinite expressions which are yet so much in use in the less advanced sciences. No engineer contents himself with saying that steel is harder than iron, or iron more ductile than lead, when he can express the hardness of the one, and the ductility of the other, in numbers, even though the numbers be mere approximations to the true numerical value of any particular specimen of these metals.

But besides its application in determining the mean properties of the materials which we employ in the arts, the numerical method is resorted to, as has been already mentioned, wherever any general result is brought about by the combined action of a number of causes which we are unable to distinguish with accuracy, and to which we can apply no certain measure. We may instance atmospheric changes produced by the joint operation of a variety of causes, and dependent upon transient influences which, taken separately, we are unable to estimate or to measure. We have recourse, therefore, to the numerical method, and having ascertained the mean value of the sum of these causes, we employ it as a foundation for reasoning, and a standard of comparison. As examples of the application of the numerical method, we may instance barology and atmology, and the sciences of the winds and tides; and the extensive series of observations which are now making on the tides at various points of our coast, and on atmospheric changes in several parts of the globe, will shew the value attached to the numerical method by those who are in the daily habit of applying more certain and powerful instruments of calculation.

The principles on which the value of the numerical method depends are extremely simple, and as this is the only form of calculation which can be applied to the vital sciences, it is important to obtain a just conception of the degree of reliance which can be placed upon it. In the application of numerical values to particular cases, observation or experiment must be employed at every step we take, and both, as we know, are subject to error. The question, therefore, naturally arises — if our observations and experiments, though assisted by the most powerful and delicate instruments, are erroneous, how is it that the sciences to which they are applied have arrived at such perfection? This perfection has been attained in spite of such errors. Though there can be no doubt that the most careful observations are liable to error, yet it is a principle, established as well by reason as by experience, that as the error may be either in excess or in defect, the one class of observations will neutralize the other, and the mean results, supposing the observations to be sufficiently numerous, will be the real quantitative values of the object or objects observed. This principle will hold good in any case, so that the natural and necessary defects of observation and experiment cannot be urged as an argument against the employment of the numerical method, even in those sciences of which the dependance on observation and experiment is the most close. But this principle of compensation is not limited in its application to the errors of observation, it applies with the same certainty to the objects themselves as to the observations made upon them; so that the mean value of a number of objects which differ numerically from each other will be the actual value of the greater number of the things observed, the extremes both in excess and in defect balancing and neutralizing each other. The numerical method, or the method of averages, therefore, on the one hand corrects the errors of observation and experiment, and on the other equalizes the value of the things observed.

These two important principles—first, that the errors necessarily existing in our observations and experiments (the consequence of the imperfection of our senses, or of our instruments) neutralize each other, and leave the actual value of the object or objects observed; and, secondly, that the extreme quantitative differences existing between the several things observed, compensate one another, and leave a mean result which accurately expresses the value of the greater number of the things so observed,—form the hinges on which the numerical method turns.

Both these principles presuppose the existence of a considerable number of observations; for, it is obvious, that if the observations are few in number, the extremes may be all in excess, or all in defect; just as the gambler, contrary to all expectation, may continue for many times in succession to turn up cards of the same colour, or throw the same high number on the dice; and again, for as many times successively to turn the reverse colour, or throw the lowest number: it is only by multiplying his throws that he learns the real chances of the table. There is another reason for increasing the number of our observations. It is that in some cases a single remarkable exception to a general rule will introduce a very high numerical value, which, considerable as it is, when divided amongst a large number of observations, makes an extremely minute addition to each of them; whilst, if the observations were few in number, that addition would be very considerable. The same remark applies with equal force, *mutatis mutandis*, to a single low numerical value.

As to the number of observations which may be sufficient in any particular case to avoid error or to determine a real average, no general rule can be laid down. Where our means or instruments of observation are imperfect, or the things observed differ widely in numerical value, a large number of observations is necessary: in other cases a smaller number may suffice. Perhaps the best rule which can be given for ascertaining whether the observations which we have collected are sufficiently numerous to yield a true average, is to divide the whole number of observations into groups of equal size, and compare them the one with the other: if the average value of each group is the same, we may safely conclude that we have arrived at the true mean; if not, we must increase the number of our observations, and the size of our groups, till the desired equality is obtained. For instance, one hundred observations having been collected, are divided into four parts, containing twenty-five observations each; if, on comparing these four parts with one another, we find that they yield the same average result, we have good reason to regard such result as the real average. But, if the average results are different, we must divide the one hundred observations into a smaller number of parts, and if necessary, increase the number of our observations. If each collection of fifty or of one hundred observations, as the case may be, yields the same average, we may confidently regard that average as the true one. Regularity of increase or decrease in a series of averages, will also afford a strong probability of the exactness of each individual average.

But if it is important to derive our averages from a large collection of observations, it is not less essential to group together those observations only which bear a close resemblance to each other. In the ordinary processes of arithmetic, as well as in the more general calculations of algebra, we take care that the unit which we assume as the basis of any calculation, whether it be an inch, a foot, a yard, or a mile, shall always have the same value; and if we represent that unit by an abstract quantity, we multiply it by whole or fractional co-efficients, but never allow it to change its original value. In like manner, in the collecting and grouping of facts, the greatest care is necessary to include in the same group those only which are identical and of equal value in respect to that property or quality which forms the basis of our classification. Thus, the botanist groups in the same class and order those plants only which have the same number of stamens and the same number of pistils; the crystallographer those crystals only which are identical both in the number and direction of their sides; and the physician those cases only which resemble each other in one or more symptoms which are supposed to be characteristic of a certain disease. These groups of facts furnish us with data for reasoning, and with materials for the formation of theories. But the absolute identity of all the facts so grouped together is essential to the accuracy of our reasoning, and to the truth of our theories. These observations apply with equal force to the grouping of those facts which form the groundwork of our numerical enquiries. Although absolute numerical identity is, from the very nature of the case, impossible, there is nothing to prevent us from obtaining the strictest resemblance in every other respect. The attainment, indeed, of this close resemblance, of this identity, in respect to all those particulars which are not variable, is obviously more necessary in numerical investigations than in any other enquiries whatever.

With these remarks on the general principles of the numerical method, and on the obvious cautions which ought to be observed in collecting the facts which are to form the basis of our calculations, I conclude this short preliminary sketch of the application of numbers to the sciences which have to do with unorganized matter.

The foregoing observations have had for their object the establishment of the great and important principle that, *the certainty of a science is exactly proportioned to the extent to which it admits of the application of numbers*. An attempt has been made to shew that abstract reasoning has provided us with instruments of calculation of absolute certainty and of infinite power; that there are certain "primary existences," such as space and time, and certain relations of matter, such as position, direction, and distance, which, being in their very nature numerical, form the natural and appropriate objects for the application of these "instruments," and that those sciences in which they are most extensively applied, are most certain. These instruments of calculation may be termed *general*, in contradistinction to those which are procured by means of experiments or observations on the different forms and states of matter, and on the several agents by which all material changes are produced. These latter may be termed *special* instruments of calculation. They are of more limited and difficult application, and in every respect more dependent on the uncertain and fallacious exercise of the senses. The sciences, therefore, in which these calculations play a prominent part, to the exclusion of the more exact instruments of calculation, hold the second place in point of certainty. Of these sciences chemistry furnishes a good example.

With the employment of these general and special instruments of calculation possible certainty ends, and probability begins. Here, too, the numerical method finds its first application, and it promises to do for variable quantities and probable events, what the pure mathematics have already done for constant quantities and certain occurrences: that is, it promises to carry the sciences of probability to the highest perfection of which they are susceptible.

It appears, then, that the first aim and object of the speculative, as well as of the practical philosopher, is to obtain precise numerical statements of all the facts established by observation and experiment; to ascertain the exact quantitative values of the objects on which he speculates, and of the materials with which he works, and until he has securely fixed these values, he feels that he has fallen short of the requirements of science. Calculation, indeed, is felt to be "the very soul of science," a necessary element of precision, a measure of the accuracy of observations and experiments, and an unerring test of the truth of theories. In one form or other it pervades all the sciences which have to do with unorganized matter, or with the various subtle and powerful agents by which the material world is governed and controlled. If numerical certainty is not attainable, numerical probability becomes its natural substitute; both are frequently employed together, and the one is often converted into the other.

The success with which calculation has been applied to unorganized matter, and the confidence with which the natural philosopher resorts to it on all occasions, have not failed to exercise a powerful influence on those who pursue the study of organized beings; and a growing disposition to apply calculation to the phenomena of life, is one of the characteristics of the age in which we live. Already has the application of the numerical method to the varying conditions and social relations of mankind given birth to a science of vast extent and of unequalled interest—the science of Statistics. This science is so comprehensive that it defies all attempt at definition, and admits of no precise or accurate limitation. Man, considered as a social being, is its object; the mean duration of his life, and the probable period of his death; the circumstances which preserve or destroy the health of his body, or affect the culture of his mind; the wealth which he amasses, the crimes which he commits, and the punishments he incurs — all these are weighed, compared, and calculated; and nothing which can affect the welfare of the society of which he is a member, or the glory and prosperity of the country to which he belongs, is excluded from its grand and comprehensive survey. As a branch of this vast subject, political economy, till lately a bye-word and a jest, is asserting its right to the character of a science, and state medicine is putting forward its claim to attention and respect.

As the greater part of the science of statistics has a more or less intimate connexion with the studies of the physician, it will be instructive to consider somewhat at length the general principles on which the value of the numerical method in its application to statistics depends.

The most important and most simple application of the numerical method is to the determination of the frequency of events, without reference to the causes, whether few or many, by which those events are brought about. The data on which the several kinds of insurance depend form the best examples of this application of numbers. Thus the data for the insurance of life are derived from calculations of the deaths occurring in a given number of persons during a given period; those for the insurance of health from calculations of the number of persons taken ill during a given period, as well as of the duration of their maladies; and insurances of property from similar calculations of the casualties to which it is exposed.

In all these cases we merely ascertain the occurrence of an event, without regarding the causes by which it is produced. But little error, therefore, can creep into our calculations; and as they are reapplied to as many cases as those from which they were originally obtained, or at least to a very large number of cases, we may predict the result with nearly as much confidence as that with which the astronomer foretells an eclipse, or the chemist the effects of a decomposition. The success attending the operations of insurance societies is a sufficient proof of the reliance which we may place on these calculations. They hold, indeed, the same place among the sciences of probability which those of the astronomer hold among the exact sciences. Their certainty arises from the simplicity of the observations required, and the vast number of facts from which the data are originally obtained, and to which they are ultimately reapplied.

Another application of the numerical method in statistical researches is to the determination of the average of a number of objects which differ in their numerical value. The natural sciences furnish numerous instances of this use of numbers. The changes which take place in the temperature, density, moisture, and electric condition of the atmosphere, in the direction of the winds, in the height of the tides, and in a variety of similar phenomena, give ample scope to the employment of the numerical method. As examples in vital statistics may be mentioned the stature and weight of the body, and the development of muscular force. In political statistics the varying prices of articles of merchandise or food. The mean results obtained in these instances are rarely reapplied to a great number of cases, except for the purposes of comparison. But whether we employ the numerical method to determine the probability of an event, or to ascertain the mean of a number of objects which differ in their numerical values, we must use the same caution in collecting and applying our facts. In either case, both the facts from which our averages are derived, and those to which they are reapplied, must be numerous.

Before we proceed to the application of mean results to individual instances, we must examine a little more minutely the value of the numerical method in its more general applications. The abstract value of the numerical method, indeed, has never yet been called in question, but had it been doubted, the success attending the institution of insurance societies would convince the most sceptical. A striking illustration of the reliance which may be placed on calculations obtained from a large number of facts, is afforded by the constancy with which the same numbers are reproduced year after year by the same combination of circumstances. An excellent example of this kind is afforded by the statistics of crime. In reference to this subject Quetelet observes, that "in all that relates to crimes, the same numbers are reproduced with a regularity which cannot be overlooked, even in the case of those crimes which would seem most likely to baffle all attempts at prediction, such as murders, which are usually the result of quarrels, arising without sufficient motive, and in circumstances, to all appearance, the most fortuitous. Nevertheless, experience proves that not only do the murders annually committed amount to nearly the same number, but even the instruments by which they are perpetrated are employed in the same proportions."* The same remark applies to the sentences passed on the criminals. Thus, in France, out of every 100 impeachments, there are 61 condemnations, and this number remains nearly constant year by year. When we reflect on the great variety of circumstances under which crimes are committed, and on the various causes which influence the sentences passed on the criminals, we cannot but be struck with the reproduction, year by year, of the same average results; and we naturally infer, that however numerous and however various may be the causes to which an event owes its existence, these causes will be accurately reproduced in equal intervals of time, so long as the same circumstances exist, and provided that the number of facts observed is sufficiently great. From this general principle we may draw the corollary, that if the aggregate circumstances vary materially in equal intervals of time, the numerical results will be different, and thus indicate the variations which have taken place. As a means of comparison, then, the numerical method offers us invaluable assistance in determining the permanence or variation of the causes which contribute to the production of any given event. One of the best illustrations which can be given of the value of statistics, as a means of comparison, is to be found in the bills of mortality. These prove, beyond a doubt, (and no loose observations expressed in ordinary language could do this,) that the average duration of human life is continually increasing, and that many of the most fearful causes of disease and death are gradually losing their power. They shew, too, the comparative salubrity of different climates and of different modes of life, and furnish in this way most useful information to the physician and to the legislator.

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* "Essai de Physique Sociale," Vol. i. p. 8.

A very obvious and most important application of statistical investigations is as a test of the truth of theories. It often happens that an event is attributed to a cause which varies in intensity under different circumstances or in different localities, and we have no other means of testing the accuracy of our opinion than by comparing the frequency of the event in question, under the varying influence of the assumed cause; and should the same numbers be obtained in every case, we are justified in rejecting that cause. If this rule be applied to the received opinions on the subject of phthisis pulmonalis, we shall soon see how void of foundation they are. It has been often stated that this disease is of more frequent occurrence, and more fatal, in cold than in warm climates. The admirable Statistical Reports of Captain Tulloch entirely disprove this assertion.* A single fact, quoted from this Report, will suffice to demonstrate the necessity of submitting these opinions to the searching test of numbers:—"Out of an aggregate strength of 86,661 (soldiers) serving in the Windward and Leeward Command, not fewer than 1,023 were attacked by that fatal disease, being 12 per 1,000 annually, while out of an aggregate strength of 44,611 Dragoon Guards and Dragoons serving in Great Britain, only 286 were attacked, being about 5½ per 1,000. Nearly the same remarkable disparity exists between the mortality from consumption in other parts of the West Indies and in our own country; and it is not less worthy of remark, that the Black Troops are still more exposed to the ravages of this disease than the Europeans themselves. It is obvious that statistical investigations alone can give us correct information on subjects such as these, and that we might have cherished the same absurd and fatal errors for centuries to come, whatever pains we might have taken to test them by common observation expressed in common language. It would not be easy to estimate the amount of evil which this error has produced. Let the weak and wasted invalid, banished from the country of his birth and of his home, obliged to forego all his cherished comforts, and to break through all his long-formed habits, to leave friends and kindred behind him, and to waste his little remaining strength in reaching the land which is doomed to be his grave—let him tell how great is the amount of suffering which such unfounded opinions as these create.

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* Statistical Report of the Sickness, Mortality, and Invaliding among the Troops in the West Indies, p. 8.

But the highest aim and best achievement of statistics is the discovery of general laws. I have already observed, that the more we increase the number of our observations, the more do individual peculiarities, and exceptions to the general rule, disappear; and the more certainly do the averages obtained represent the normal condition of the objects observed. These averages admit of strict comparison the one with the other, and this comparison discovers laws closely resembling in form and character the laws which preside over dead matter. Thus Quetelet * remarks, that " the curve of viability" (the line which indicates the probability of living at different ages), " bears a singular resemblance to that of the tendency to crime, and a resemblance still greater to that of the development of forces." In like manner the obstacles which oppose the increase of population, act precisely in the same way as the resistance which is offered to a moving body by the medium in which it moves. The curve, too, which represents the mortality of small-pox at the several periods of its duration, is, like the curves which represent increasing and decreasing material forces, a regular one.† The following observations of Quetelet deserve attention, as they place in a very striking light the strong analogy which exists between the laws established by the aid of statistics, and those which have been obtained by abstract reasoning or by experiment:—" All observation tends to confirm the truth of that proposition which I long since announced, that *that which concerns the human race, considered collectively, is of the order of physical facts;* the greater the number of individuals, the more completely does the will of individuals disappear, and allow the series of general facts, which depend upon the causes by which society exists and is preserved, to predominate. These are the causes which we have to seize, and, when they are known, we determine their effects upon society just as we determine effects by their causes in the physical sciences. We must admit, however afflicting this truth may, at first sight, appear, that *on submitting to careful experiment unorganized bodies, and the social system, we are unable to say on which side causes act in their effects with the greatest regularity.*" ‡

But though the statistical method were of limited application, and of doubtful utility in all other respects, it would possess a high value as a means of insuring accuracy. Hitherto the sciences which have to do with unorganized matter, and especially the mixed mathematical sciences, have owed their superior certainty not merely to the ease with which they allowed of the application of numbers, and to the strictness of their definitions, but in a great degree to the substitution of signs and symbols for words of variable and uncertain import. Statistics have introduced the same precision into the vital sciences, and had they effected nothing more than the substitution of figures for words, they would have established a strong claim to our approbation. Nothing can be more variable or worse defined than the meaning of the words which have been hitherto employed by the physician in his description of disease, or in his statement of the results of the treatment he has adopted. What meaning are we to attach to such vague terms as "sometimes," "occasionally," "generally," "in the majority of cases?" These terms, as every one knows, have every possible signification, and vary in their meaning with the varying disposition, and more or less sanguine character of those who use them. The "sometimes" of the cautious is the "often" of the sanguine, the "always" of the empiric, and the "never" of the sceptic; but the numbers 1, 10, 100, 1000, have but one meaning for all mankind. If, then, for no other reason than the one now assigned, the attainment of accuracy, the numerical method ought to be employed wherever it can by possibility be applied.

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* Quetelet, Op. cit. Vol. i. p. 173. † British Medical Almanack, for 1838.
‡ Ibid. Vol. ii. p. 247.

The application, then, of the numerical method to living beings, in all their social relations, constitutes the science of statistics. Some of these relations form objects of research to the moral philosopher—others to the physician—others again to the political economist—but all of them to the legislator. The examples which have been adduced, will serve to shew how large a part of the science of statistics is connected with the studies of the physician. In addition to the knowledge of disease affecting individuals which may be obtained from this source, he derives from it all his information as to the best means of preserving the health and prolonging the life of communities. This most important study has been greatly neglected, on the one hand, by the physician, who is the only person prepared to pursue it with advantage, and, on the other hand, by the legislature, which alone can effectually apply the knowledge furnished by the physician. We may venture to indulge the hope, that when statistical researches shall have brought the science of hygieine to the perfection of which it seems susceptible, governments will not be backward to make a practical application of the knowledge which has been acquired. If it were possible to express by figures the waste of human life occasioned by the absence of legislation on the one hand, and by the existence of absurd and mischievous laws on the other, the government of our country would not incur the heavy responsibility and deep disgrace of being totally indifferent to the lives of its subjects.

Statistics, then, considered as a speculative science, will scarcely suffer by a comparison with the most perfect of the mixed mathematical sciences. The mean results which it obtains are almost as constant as the numerical values determined by the experiments of the natural philosopher, and the former are reproduced with almost as much certainty by a recurrence of the same circumstances as the latter are by a repetition of the same experiments. The laws, too, which statistics discover, have all the regularity and symmetry of the laws which are established by observation or experiment. For all the purposes of reasoning or comparison, therefore, the calculations of statistics may be employed with confidence; whilst the precision arising from the introduction of numbers in the place of words, forms by no means the least among the advantages which it offers. Considered, on the other hand, as a practical science, statistics will bear a comparison with the most certain of the sciences of experiment and calculation, provided always that the mean results which have been obtained from a large collection of facts, are re-applied to facts equally numerous, or, at all events, to facts sufficiently numerous to include the several numerical values which have been encountered in the original calculation.

Although the justice of the preceding observations may be readily admitted, and the value of the numerical method as an instrument of discovery, a mean of comparison, and a test of the truth of theories may be conceded, considerable doubts may still be entertained as to the possibility of applying our average results to the studies of the physician, and especially to the practice of medicine. And here the first enquiry which suggests itself is, how far do the functions of living beings, in health and disease, admit of the application of numbers? Is the numerical method as applicable to living beings as to unorganized matter? We need not hesitate to answer in the affirmative. The profession of medicine gives ample scope for the application of numbers If we consider the health of large masses of men placed under different circumstances, and acted on by different influences, it is to the numerical method that we must look for accurate information as to the effect of these circumstances. If we would compare one human body with another in respect of stature, weight, muscular force, or the development of its several parts, we must also resort to the numerical method. If, again, we direct attention to the several functions performed by the human body in a state of health, we find that most of them can only be adequately described by the aid of numbers. Thus the amount of the injesta and egesta, the quantity of the several secretions, the products of the respiratory process, the frequency of the pulse and respiration — none of these can be expressed without the aid of numbers. If, from the state of the body in health, we pass to a consideration of its diseased conditions, we meet with the same necessity for the employment of calculation. The prevalence of the several causes of disease in different countries, and under different circumstances, their period of incubation, the length of their course, their fatality—these, and a great number of similar instances are, strictly speaking, numerical. Then, as to the action of remedies, and the relative advantage of different modes of treatment—nothing can determine these but an accurate and numerical comparison of their fatality and duration under the several methods of treatment recommended. These are a few, and but a few, of the instances in which the numerical method is the only one from which we can hope to obtain any valuable information; but these few examples will suggest to every experienced man a thousand other cases in which the employment of this method cannot fail to lead to most important results. But it is quite unnecessary to accumulate instances; if numbers were invariably substituted for words of doubtful meaning, scarcely a page of any medical treatise would be without its figures.

But, it may be asked, what good purpose will this substitution of figures for words accomplish? Will it enable the physician or the surgeon to treat individual cases of disease with more success, or to anticipate their results with greater confidence? In other words, does the numerical method admit of application to individual cases? It must be conceded by the most strenuous advocate of this method, that such application is limited. For it is self-evident that as our averages have been themselves procured from a great number of objects differing in their numerical value, if we attempt to apply these averages to individual cases we shall encounter over again all the varieties from which our original numbers were obtained. And it would be as absurd to attempt to determine the event of a particular case of disease by the average result of a great number of cases, as it would be to attempt to foretel the period of an individual's death by the bills of mortality, or the amount of his fortune by the average wealth of the community to which he belongs. The fallacy of such application is not more apparent in the practice of medicine than it would be in the science of meteorology. It is just as ridiculous to attempt to measure the result of a single case of disease by the application of an average, as it would be to foretel the quantity of rain which will fall in a given place on a given day by means of the average quantity which falls in the course of a year. There is one consideration, indeed, which renders the application of mean values to individual cases more liable to error in medicine than in other sciences, viz., the remarkable exceptions to general rules, which are peculiar to life and living beings. We know that the food of one man is the poison of another; that a medicine which shall act as a purgative in one person, shall produce the effect of a narcotic in another; and that a substance which shall cause exquisite pain to one man, shall not occasion the slightest inconvenience to another. These and other idiosyncrasies, though of comparatively rare occurrence, will occasion greater difficulty in the application of general results to individual cases, than is encountered by the natural philosopher in his practical applications to the most uncertain of the sciences which form the subject of his study.

But there is still another cause which prevents the application of our averages to individual cases; and that is the wide difference which exists between our mean and our extreme numbers. Thus, to take a familiar instance:—The duration of human life may extend from a moment to upwards of a century and a half, and any attempt to predict the duration of the life of an individual by the use of the average would be regarded as in the highest degree preposterous. Another illustration of a totally different kind is afforded by the pulse, which, in persons of the same age, and in a state of rest, has a range of about 40 beats;* and in the same individual, under different circumstances of excitement, a range at least equal to its frequency in a state of rest. Any attempt, therefore, to apply an average frequency to a particular case must be regarded as unreasonable. In this respect the application of the numerical method to dead matter may often be made with much greater confidence, for it frequently happens that the extreme are not very remote from the mean results. Thus, for instance, the engineer knows that the friction produced by the contact of iron, or of any other material employed in his machinery, is different for different specimens of that material; but he finds that the mean quantity of friction produced differs little from the extreme, and he applies the average value with a certainty that no very material practical error will take place in the working of his machines. Such cases as these rarely occur in the study of physic; the application of mean values to individual cases must therefore be extremely limited.

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* This calculation is made from some unpublished observations on the frequency of the pulse at different ages.

But though the mean values admit of very limited application to individual instances, it is not so with the extreme values. These may be applied with confidence and with advantage. For instance, supposing that a great number of observations have determined the earliest and the latest period at which a poison begins to act, any symptom, arising in a suspicious case, before or after those two points of times may be reasonably attributed to other causes, especially if the observations which we have collected are numerous; for on the number of the observations in these and all such cases depends the value of our conclusion. Sometimes, again, we may obtain important information by a comparison of the extremes of two numerical series. Thus, in the case of the static lung-test, the smallest weight of lungs which have respired being taken, and the greatest weight of such as have breathed being noted, any number falling short of the one, or exceeding the other extreme, will give the highest probability, in the one case, that the child had not breathed, and in the other that it had; and whenever the number ascertained in any particular case approaches either extreme, we are justified in speaking with a confidence proportioned to the closeness of the approximation. The result of some observations, not yet published, on the effect of posture on the pulse, furnish an excellent example of the application of extreme numerical results to individual instances. In cases of consumption I have had occasion to observe that the greatest effect produced upon the pulse by a change from sitting to standing is less than the least effect produced by the same change on the same frequency of pulse in healthy persons. If this circumstance shall prove to be common to a few other diseases with which it is possible to confound this affection of the chest, this peculiarity of the pulse will enable us to ascertain that any suspected case belongs to one of those diseases; but should it prove peculiar to phthisis, an important means of diagnosis will be added to those we already possess.

These few examples will prove that the extreme values obtained by the numerical method admit of important practical application; but with these exceptions, to which I have thus briefly alluded, the application of numerical values to particular cases is apt to mislead us; but it is not more likely to mislead than a reliance upon general though strong impressions, sometimes made by many and sometimes by few observations, which impressions, when promptly acted on, constitute what is called tact—a gift invaluable to its possessor, but useless to all the world besides. In his treatment of individual cases, the physician has constant opportunities of applying this valuable talent, and it is to him what common sense is to men in the ordinary affairs of life,—reason acting without rule;—it is a prompt application of experience already acquired to the particular circumstances of an individual case. But if we closely examine this talent, we shall perceive that it is a rough calculation of chances, in which all the elements of the calculation are rapidly seized and accurately estimated. The object of the numerical method is to supply the want of tact by furnishing the inexperienced with accurate calculations of the probable event of different diseases, and the probable consequences of different modes of treatment. These calculations supply but one element for the solution of the problem, for they apply only to cases of average severity; they leave to the experience of the physician the task of ascertaining all the circumstances in which any particular case departs from the average severity. After all, then, the numerical method leaves many occasions for the exercise of that peculiar tact which constitutes the essential difference between the successful and unsuccessful practitioner of our art.

In discussing the advantages of the numerical method, I have already noticed some of the objections which may be urged against it. The opponents of this method, without attempting to deny its abstract value, are wont to bring forward its fallacies as arguments against its employment. It might be expected, therefore, that I should enter into some discussion of the numerous errors with which the statistician stands charged, and defend him and his method against the objections as well as the ridicule of his opponents. This, however, I have no intention of doing, as the slightest reflection must convince the most sceptical that the errors which occur in statistical investigations are precisely those to which the results of common observation, expressed in common language, are equally exposed. The defects of the numerical method are, in fact, the defects of observation and experiment, its excellencies are peculiar to itself. The only difference existing between the more ordinary methods and that which I venture to advocate is in the strictness of the terms employed. To prove that the errors of the numerical method are in no respect dissimilar from those of common observation, I may advert to the well-known instance of the Government Annuities, which being calculated on the mean duration of human life under ordinary circumstances, were applied to picked cases. Here the error committed (and a most serious loss it entailed on Government) was that of a man who should apply general impressions of the fatality of a disease, obtained from an inspection of all the cases, without any exception, which had come under his care, to the most favourable examples only of that disease. This error is of daily occurrence, and is certainly as liable to occur to the advocate as to the opponent of the numerical method. Dr. Bisset Hawkins' work on Medical Statistics supplies us with one or two examples. He compares, for instance, the mortality of the adult French prisoners in this country, during the year 1813, with the mortality of the entire population of Rome; and the health of the picked garrison of Gibraltar with that of some of the cities on the Continent.* In these cases the comparison would not have been less exact if words had been substituted for figures; the error was in the reasoning, and not in the form of expression.

Another striking illustration of the identity of the errors of common observation with those of the numerical method is afforded by Dr. Bryan Robinson,† one of the first persons who applied the numerical method to the investigations of the functions of the human body. Robinson thought that the stature of the body had a considerable influence on the pulse. Accordingly, he made a number of observations on the pulse of persons of different statures, the lowest point of his scale being formed by young children, and the highest by full-grown adults. He found that as the stature increased the pulse diminished in frequency, and that there was a striking approach to regularity in the rate of decrease. He accordingly set to work to discover an empirical formula for calculating the frequency of the pulse from the height of the body, and found "that the mean pulses of regular-proportioned bodies are to one another as the biquadrate roots of the cubes of the lengths of the bodies." Here the fault committed is obvious — the effect of age was entirely overlooked. In order that his observations should decide the point, it was necessary that the ages of the parties examined, as well as all other known causes of variation, should be equal, but their statures different. In this instance the error committed was that with which an ordinary observer or experimenter would be chargeable, who should decide upon the influence of a supposed cause, without making all other causes with which he was acquainted equal in the several cases observed. In whatever way, then, an observer may choose to express the results of his observations and experiments, whether he employs ordinary language, or resorts to numbers, he must guard against the same errors, he must use the same precautions. The ordinary observer, no less than the statistician, may make an unwise choice of a subject of investigation, and devote himself to some childish puerility; and when he has chosen a subject, he may observe without care, and experiment without a plan; he may group together dissimilar facts, deduce from them wrong principles, and make absurd applications of his general laws to individual instances: but his errors will be the same, whatever may be the mode of expression which he adopts; the only difference will be, that error will contrast more strongly with the strict expression of the numerical method, than with the loose and ill-defined phrases of common observation.

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* Pp. 160, 215.

† Animal Economy, p. 269.

In the foregoing sketch, I have confined myself much less strictly than some might deem desirable to the application of the numerical method to medicine. The sciences are so closely connected with each other, and the methods of investigation which they adopt are so similar, that our choice of illustrations will be best guided by the degree of confidence which we place in them. For this reason, and that I might entrench myself behind a strong defence, I have availed myself of illustrations drawn from the more exact sciences, and have alluded to the sources of their perfection. Those who know nothing of the methods of investigation which these sciences make use of, pay deference to their high authority; they believe in the perfection of astronomy because they see the fulfilment of her predictions; they admit the power of chemistry because they see the marvels which she accomplishes; and they cannot but respect the methods by which these sciences have attained their present certainty. This certainty, as I have endeavoured to prove, is entirely due to the extent to which they admit of the application of numbers. The more perfect our instruments of calculation, and the more simple the observations to which they are applied, the more perfect are the resulting sciences; and as our instruments become less perfect, and our observations more difficult and more entangled, so does science become less certain, less theoretically true, and less practically useful. Still, however difficult our observations, and however complex our facts, certainty is always possible so long as the objects to which our calculations are applied are naturally identical, or can be artificially brought to an exact resemblance with each other.

Where identity ceases, there certainty ends, and probability begins; and there too the numerical method finds its first application. And it is most worthy of remark that the student of the exact sciences, who is familiar with the use of the most certain instruments of calculation, has never hesitated to apply the numerical method, and has required no arguments to convince him of its advantages; whilst the medical man, whose science seems most to need the application of such a method, and to offer abundant occasions for its employment, still doubts its efficacy, and prefers the obscurity of general phrases to the clearness and precision of numbers. Does not the simple fact, that medicine required a Louis to teach the advantages of the "methode numerique," and to set an example of its employment, so long after its introduction into the more advanced sciences, prove the necessity of making those sciences an example to our own? The certainty, indeed, to which the exact sciences have attained, is sometimes attributed to other causes; but the slightest reflection will convince us that calculation is the sole source of their superiority. For though the amount of knowledge which has been acquired strike us with astonishment, and the certainty with which it is applied to the prediction of future events produce a feeling approaching to awe, yet we have only to examine more closely to find that the best of that knowledge is rather an acquaintance with numbers, and relations, and proportions, and sequences, than with the real nature and essence of things; and that man's boasted mastery over nature is obtained by skilfully dividing her empire, and setting kingdom against kingdom, and power against power, eliciting from one form or combination of matter, the means whereby to vanquish and control another; in all things the minister and humble imitator of Nature, but hopeless of being admitted to a knowledge of her secrets. Of what use would be the noblest of our theories if calculation did not give them a practical value? Reduce gravity, from a numerical theory, to the bare expression of the fact that all bodies attract each other, and what service would it render to the astronomer? Convert the theory of definite proportions to a vague and general expression, and what advantage would the chemist derive from it? Rob science of calculation, and we degrade it to an art; introduce a numerical theory into the most confused assemblage of facts, and they start at once into a science. Without calculation the most comprehensive theory may remain almost barren of practical results. What, for instance, has the beautiful theory of the circulation of the blood done for medicine? It has not taught us the use of the lancet, for that was in requisition long before the time of Harvey, and we treat inflammation now as we did in the days of Hippocrates. As an acknowledged fact, indeed, the circulation of the blood has had an indirect influence upon other medical theories, but what direct practical application does it boast? Where are we to find a measure of the state of the circulation itself? The pulse, the only measure we possess, scarcely gives us more information now than it gave to Celsus, more than eighteen centuries ago. Its changes are still as difficult to appreciate, and not less difficult to describe; and though Floyer invented the pulse-watch, and Heberden strongly recommended its employment, how little has yet been done to bring to perfection this imperfect measure of the circulation!

Medicine, again, possesses, in the theory of Jenner (I use the term theory in the sense of the expression of a general fact), an instrument of extensive usefulness, but we sought in vain for any measure of its value till the numerical method was applied to it. It is the employment of numbers which alone can enable us to form a just estimate of the benefit which vaccination confers, and of the extent of the protection which it gives. These examples will suffice to prove that the imperfect state of medicine is not due to the dearth of true and comprehensive theories, but to the want of a numerical measure of the theories themselves.

It is important to distinguish medicine considered as an *art* from medicine considered as a *science.* As a practical art it must necessarily remain imperfect; as a theoretical science there is nothing to prevent it from attaining a high degree of perfection; and we may rest assured that every addition made to our science will be a gain to our art. Without venturing to foretel the amount of the advantages which calculation may confer on physiology and medicine, we may safely assert, that in exact proportion to the difficulties which beset the study of any science ought to be the precision of the methods which it employs, and there can be no doubt that numbers are more precise than words. On this superiority of numbers to words the advocate of the numerical method may safely rest its claims to general acceptance, and its right to supersede all other methods of investigation.

Though the question proposed at the beginning of this essay has now received a partial answer, other causes of the uncertainty of medicine remain to be noticed. What is the reason, then (exclusive of its neglect of calculation), that medicine still remains a conjectural art? Is it because she has not yet collected facts enough? There is no science, however perfect, which can boast of possessing so vast a store. Is it that time has not yet ripened the fruits of observation and experiment? No science can boast so high an antiquity. Is it that the objects to which she devotes her attention are not important enough to stimulate the industry of her votaries? What object can be more important, what task more noble than the alleviation of suffering and the restoration of health? What strong motive to exertion can be proposed which medicine does not hold forth? Where, then, shall we seek for the causes of its uncertainty? Its practical character, the chief source of its value, is the very element of its weakness. If medicine were less exclusively a practical *art* it would soon become a more perfect *science.* If the alternatives of ease or suffering, of life or death, did not depend upon the treatment which the medical man adopts, he would be more willing to try the efficacy of new methods of cure—if, in fact, individual cases hold a less prominent place in his thoughts, he would direct more attention to the discovery of general laws. But this practical character of our art has other disadvantages; this too exclusive attention to detached facts makes the medical man impatient of all investigations which have no obvious and immediate practical bearing. It is this which prompts the incessant enquiry, *cui bono ?* addressed to all those who desert the beaten paths of practical routine, though in the hope of returning enriched by the spoils of new and promising enquiries. I would not be understood to undervalue the labours of the practical man. I wish merely to point out an error into which he is liable to fall. But there is still one other defect necessarily inherent in an exclusively practical *art*, and more especially in our own. The application of the few general principles which we possess to individual cases is so uncertain that it leads to a desponding view of the future progress of our profession. It leads us to despair of ever placing our own science, if indeed it may be called a science, in the proud position occupied by the more certain sciences; it makes us lose sight of that beautiful description of the true philosopher, which one of the truest and most distinguished philosophers of our own time has sketched—the character of hoping all things not impossible, and believing all things not unreasonable. If we must needs despair of the future progress of our art, let us at least have better reasons than those we now possess for indulging our despondency. Let us adopt those strict and rigorous methods of investigation, those clear definitions of the terms we use, those accurate instruments of measurement, the application of which has raised other sciences to such certainty and perfection; and should these fail, then, and not till then, we may safely assume that the structure and functions of the human body are so complicated, and the subtle principle which guides and regulates the human frame so incomprehensible, that steady industry, and patient thought, and subtle and comprehensive reasoning shall, for once in the history of science, be lavished in vain.

ON RAILWAYS IN BELGIUM.

THE attention of the public has been recently attracted to the subject of the establishment of a general system of railways in Ireland, and opinion appears to be much divided as to the policy of the Government interfering either to promote or regulate this undertaking. It would not be fitting in this place to discuss the arguments which have been advanced on both sides of this question; but the experience of the European state which has first adopted a government system of railway communication, may throw some light upon the subject, and in some degree tend to the settlement of a question which is of momentous importance to Ireland, and which, in conjunction with other measures at present in operation, holds out the prospect of great and lasting improvement to that country.

Belgium is the first state in Europe which has established a general system of railways, embracing the whole of the kingdom, and planned and executed by the Government at the public cost. The project was first put forth in the year 1833, and the object proposed was to unite the principal commercial towns on one side with the sea, and on the other with the frontiers of France and Prussia. In this respect Belgium is most favourably situated for the experiment of a general system of railways: it is of a compact form, of moderate extent, surrounded on three of its sides by active commercial nations, and on the fourth by the sea, which separates it only by a few hours' voyage from England. On its western side are the two large and commodious ports of Antwerp and Ostend, and its eastern frontier is only a few leagues distant from the Rhine, by which it becomes united to Southern and Midland Europe. Hence it possesses a near market for its productions,